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Identifying convection embedded in warm conveyor belts from satellite observations and high-resolution simulations

Annika Oertel, Maxi Boettcher, Hanna Joos, and Heini Wernli
ETH Zürich, Institute for Atmospheric and Climate Science, Switzerland (annika.oertel@env.ethz.ch)

In all seasons, convection can be an essential element of synoptic-scale extratropical cyclones, in particular in the vicinity of the associated surface fronts. Air mass ascent, and the formation of clouds and precipitation in extratropical cyclones is mainly driven by the large-scale dynamics, leading to the comparatively slow but strong slantwise ascent of moist air in the so-called warm conveyor belt (WCB). However, in sub-regions of the WCB, where ascending air parcels reach positive buoyancy, embedded convection can occur, leading to a much faster quasi-vertical ascent and intense local precipitation. Together, this flow situation has been described by the "elevator-escalator concept", where the two terms refer to fast vertical ascent by convection and slower slantwise ascent by large-scale forcing, respectively.

This presentation will briefly explain why WCBs are relevant for both surface precipitation and large-scale flow dynamics, and subsequently present two complementary pathways to identify the occurrence of embedded convection in WCBs using (i) satellite observations and (ii) convection-permitting simulations.

We first analyse the structure and relative frequency of deep convection embedded in WCBs based on geostationary satellite data for a case study with a strong WCB in the North Atlantic region. A satellite cloud classification retrieval with high spatial and temporal resolution is combined with WCB trajectories which are defined as trajectories with an ascent of at least 600 hPa within 48 hours. The satellite data show that, although the WCB region is dominated by a large-scale cirrus shield, embedded deep convection is frequently detected by the satellite. Deep convection is particularly frequently identified in the WCB inflow region at low levels ahead of the cold front, but also during the WCB ascent phase and in the outflow region. A sophisticated trajectory-based technique is introduced, which enables us to quantify how many satellite cloud pixels classified as cirrus can be regarded as likely remnants of previous deep convective clouds.

Overall, for the case considered this observational analysis indicates that deep convection can be frequently embedded in WCBs and thus can potentially modify the large-scale flow. The frequent occurrence of embedded convection in WCBs is corroborated in the second part by a preliminary analysis of online trajectories in convection-permitting simulations with the weather prediction model COSMO. Two modes of fast and slower WCB-like ascent can be identified, which is in qualitative agreement with the "elevator-escalator" concept.